CHAPTER 16

SYSTEMS ENGINEERING PLANNING

16.1 WHY ENGINEERING PLANS?

Systems engineering planning is an activity that has direct impact on acquisition planning decisions and establishes the feasible methods to achieve the acquisition objectives. Management uses it to:

- Assure that all technical activities are identified and managed,
- Communicate the technical approach to the broad development team,
- Document decisions and technical implementation, and
- Establish the criteria to judge how well the system development effort is meeting customer and management needs.

Systems engineering planning addresses the scope of the technical effort required to develop the system. The basic questions of "who will do what" and "when" are addressed. As a minimum, a technical plan describes what must be accomplished, how systems engineering will be done, how the effort will be scheduled, what resources are needed, and how the systems engineering effort will be monitored and controlled. The planning effort results in a management-oriented document covering the implementation of program requirements for system engineering, including technical management approaches for subsequent phases of the life cycle. In DoD it is an exercise done on a systems level by the government, and on a more detailed level by contractors.

Technical/Systems Engineering Planning

Technical planning may be documented in a separate engineering management plan or incorporated into a broad, integrated program management plan. This plan is first drafted at project or program inception during the early requirements analysis effort. Requirements analysis and technical planning are inherently linked, because requirements analysis establishes an understanding of what must be provided. This understanding is fundamental to the development of detailed plans.

To be of utility, systems engineering plans must be regularly updated. To support management decision making, major updates will usually occur at least just before major management milestone decisions. However, updates must be performed as necessary between management milestones to keep the plan sufficiently current to achieve its purpose of information, communication, and documentation.

16.2 ELEMENTS OF TECHNICAL PLANS

Technical plans should include sufficient information to document the purpose and method of the systems engineering effort. Plans should include the following:

- An introduction that states the purpose of the engineering effort and a description of the system being developed,
- A technical strategy description that ties the engineering effort to the higher-level management planning,

- A description of how the systems engineering process will be tailored and structured to complete the objectives stated in the strategy,
- An organization plan that describes the organizational structure that will achieve the engineering objectives, and
- A resource plan that identifies the estimated funding and schedule necessary to achieve the strategy.

Introduction

The introduction should include:

Scope: The scope of the plan should provide information concerning what part of the big picture the plan covers. For example, if the plan were a DoD program office plan, it would emphasize control of the higher-level requirements, the system definition (functional baseline), and all activities necessary for system development. On the other hand, a contractor's plan would emphasize control of lower-level requirements, preliminary and detail designs (allocated and product baselines), and activities required and limited by the contractual agreement.

Description: The description of the system should:

- Be limited to an executive summary describing those features that make the system unique,
- Include a general discussion of the system's operational functions, and
- Answer the question "What is it and what will it do?"

Focus: A guiding focus for the effort should be provided to clarify the management vision for the development approach. For example, the focus may be *lowest cost to obtain threshold requirements, superior performance within budget, superior standardization for reduced logistics, maximum use of the open systems approach to reduce cost*, or the like. A focus statement should:

- Be a single objective to avoid confusion,
- Be stated simply to avoid misinterpretation, and
- Have high-level support.

Purpose: The purpose of the engineering effort should be described in general terms of the outputs, both end products and life-cycle enabling products that are required. The stated purpose should answer the question, "What does the engineering effort have to produce?"

Technical Strategy

The basic purpose of a technical strategy is to link the development process with the acquisition or contract management process. It should include:

- Development phasing and associated baselining,
- Key engineering milestones to support risk management and business management milestones,
- Associated parallel developments or product improvement considerations, and
- Other management generated constraints or high-visibility activities that could affect the engineering development.

Phasing and Milestones: The development phasing and baseline section should describe the approach to phasing the engineering effort, including tailoring of the basic process described in this book and a rationale for the tailoring. The key milestones should be in general keeping with the technical review process, but tailored as appropriate to support business management milestones and the project/program's development phasing. Strategy considerations should also include discussion of how design and verification will phase into production and fielding. This area should identify how production will be phased-in (including use of limited-rate initial production and long lead-time purchases), and that initial support considerations require significant coordination between the user and acquisition community.

Parallel Developments and Product Improvement: Parallel development programs necessary for the system to achieve its objectives should be identified and the relationship between the efforts explained. Any product improvement strategies should also be identified. Considerations such as evolutionary development and preplanned product improvement should be described in sufficient detail to show how they would phase into the overall effort.

Impacts on Strategy

All conditions or constraints that impact the strategy should be identified and the impact assessed. Key points to consider are:

- Critical technologies development,
- Cost As an Independent Variable (CAIV), and
- Any business management directed constraint or activity that will have a significant influence on the strategy.

Critical Technologies: Discussion of critical technology should include:

- Risk associated with critical technology development and its impact on the strategy,
- Relationship to baseline development, and
- Potential impact on the overall development effort.

Cost As an Independent Variable: Strategy considerations should include discussion of how CAIV will be implemented, and how it will impact the strategy. It should discuss how unit cost, development cost, life cycle cost, total ownership cost, and their interrelationships apply to the system development. This area should focus on how these costs will be balanced, how they will be controlled, and what impact they have on the strategy and design approach.

Management Issues: Management issues that pose special concerns for the development strategy could cover a wide range of possible issues. In general, management issues identified as engineering strategy issues are those that impact the ability to support the management strategy. Examples would include:

- Need to combine developmental phases to accommodate management driven schedule or resource limitations,
- Risk associated with a tight schedule or limited budget,
- Contractual approach that increases technical risk, and
- Others of a similar nature.

Management-dictated technical activities—such as use of M&S, open systems, IPPD, and others—should not be included as a strategy issue unless they impact the overall systems engineering strategy to meet management expectations. The strategy discussion should lay out the plan, how it dovetails with the management strategy, and how management directives impact it.

Systems Engineering Processes

This area of the planning should focus on how the system engineering processes will be designed to support the strategy. It should include:

- Specific methods and techniques used to perform the steps and loops of the systems engineering process,
- Specific system analysis and control tools and how they will be used to support step and loop activities, and
- Special design considerations that must be integrated into the engineering effort.

Steps and Loops: The discussion of how the systems engineering process will be done should show the specific procedures and products that will ensure:

- Requirements are understood prior to the flow-down and allocation of requirements,
- Functional descriptions are established before designs are formulated,
- Designs are formulated that are traceable to requirements,
- Methods exist to reconsider previous steps, and
- Verification processes are in place to ensure that design solutions meet needs and requirements.

This planning area should address each step and loop for each development phase, include identification of the step-specific tools (Functional Flow Block Diagrams, Timeline Analysis, etc.) that will be used, and establish the verification approach. The verification discussion should identify all verification activities, the relationship to formal developmental T&E activities, and independent testing activities (such as operational testing).

Norms of the particular technical area and the engineering processes of the command, agency, or company doing the tasks will greatly influence this area of planning. However, whatever procedures, techniques, and analysis products or models used, they should be compatible with the basic principles of systems engineering management as described earlier in this book.

An example of the type of issue this area would address is the requirements analysis during the system definition phase. Requirements analysis is more critical and a more central focus during system definition than in later phases. The establishment of the correct set of customer requirements at the beginning of the development effort is essential to proper development. Accordingly, the system definition phase requirements analysis demands tight control and an early review to verify the requirements are established well enough to begin the design effort. This process of control and verification necessary for the system definition phase should be specifically described as part of the overall requirements analysis process and procedures.

Analysis and Control: Planning should identify those analysis tools that will be used to evaluate alternative approaches, analyze or assess effectiveness, and provide a rigorous quantitative basis for selecting performance, functional, and design requirements. These processes can include trade studies, market surveys, M&S, effectiveness analyses, design analyses, QFD, design of experiments, and others.

Planning must identify the method by which control and feedback will be established and maintained. The key to control is performance-based measurement guided by an event-based schedule. Entrance and exit criteria for the event-driven milestones should be established sufficient to demonstrate proper development progress has been completed. Event-based schedules and exit criteria are further discussed later in this chapter. Methods to maintain feedback and control are developed to monitor progress toward meeting the exit criteria. Common methods were discussed earlier in this book in the chapters on metrics, risk management, configuration management, and technical reviews.

Design Considerations: In every system development there are usually technical activities that require special attention. These may come from management concerns, legal or regulatory directives, social issues, or organizational initiatives. For example, a DoD program office will have to conform to DoDD 5000.2-R, which lists several technical activities that must be incorporated into the development effort. DoD plans should specifically address each issue presented in the Program Design section of DoD 5000.2-R.

In the case of a contractor there may be issues delineated in the contract, promised in the proposal, or established by management that the technical effort must address. The system engineering planning must describe how each of these issues will be integrated into the development effort.

Organization

Systems engineering management planning should identify the basic structure that will develop the system. Organizational planning should address how the integration of the different technical disciplines, primary function managers, and other stakeholders will be achieved to develop the system. This planning area should describe how multidisciplinary teaming would be implemented, that is, how the teams will be organized, tasked, and trained. A systems-level team should be established early to support this effort. Roles, authority, and basic responsibilities of the system-level design team should be specifically described. Establishing the design organization should be one of the initial tasks of the system-level design team. Their basic approach to organizing the effort should be described in the plan. Further information on organizing is contained in a later chapter.

Resources

The plan should identify the budget for the technical development. The funds required should be matrixed against a calendar schedule based on the event-based schedule and the strategy. This should establish the basic development timeline with an associated high-level estimated spending profile. Shortfalls in funding or schedule should be addressed and resolved by increasing funds, extending schedule, or reducing requirements prior to the plan preparation. Remember that future analysis of development progress by management will tend to be based on this budget "promised" at plan inception.

16.3 INTEGRATION OF PLANS – PROGRAM PLAN INTERFACES

Systems engineering management planning must be coordinated with interfacing activities such as these:

- Acquisition Strategy assures that technical plans take into account decisions reflected in the Acquisition Strategy. Conflicts must be identified early and resolved.
- Financial plan assures resources match the needs in the tech plan. Conflicts should be identified early and resolved.
- Test and Evaluation Master Plan (TEMP) assures it complements the verification approach. It should provide an integrated approach to verify that the design configuration will meet customer requirements. This approach should be compatible with the verification approach delineated in the systems engineering plan.
- Configuration management plan assures that the development process will maintain the system baselines and control changes to them.
- Design plans (e.g., electrical, mechanical, structural, etc.) coordinates identification of IPT team composition.
- Integrated logistics support planning and support analysis coordinates total system support.
- Production/Manufacturing plan to coordinate activities concerning design producibility, and follow-on production,
- Quality management planning assures that quality engineering activities and quality management functions are included in system engineering planning,
- Risk management planning establishes and coordinates technical risk management to support total program risk management.
- Interoperability planning assures interoperability suitability issues are coordinated with system engineering planning. (Where interoperability is an especially critical requirement such as, communication or information systems, it should be addressed as a separate issue with separate integrated teams, monitoring, and controls).
- Others such as M&S plan, software development plan, human integration plan, environment, safety and health planning, also interface.

Things to Watch

A well developed technical management plan will include:

- The expected benefit to the user,
- How a total systems development will be achieved using a systems engineering approach,
- How the technical plan complements and supports the acquisition or management business plan,
- How incremental reviews will assure that the development stays on track,
- How costs will be reduced and controlled,
- What technical activities are required and who will perform them,
- How the technical activities relate to work accomplishment and calendar dates,
- How system configuration and risk will be controlled,
- How system integration will be achieved,
- How the concerns of the eight primary life cycle functions will be satisfied,
- How regulatory and contractual requirements will be achieved, and
- The feasibility of the plan, i.e., is the plan practical and executable from a technical, schedule, and cost perspective.

16.4 SUMMARY POINTS

- Systems engineering planning should establish the organizational structure that will achieve the engineering objectives.
- Planning must include event-based scheduling and establish feedback and control methods.
- It should result in important planning and control documents for carrying out the engineering effort.
- It should identify the estimated funding and detail schedule necessary to achieve the strategy.
- Systems engineering planning should establish the proper relationship between the acquisition and technical processes.

APPENDIX 16-A

SCHEDULES

The event-based schedule, sometimes referred to as the Systems Engineering Master Schedule (SEMS) or Integrated Master Schedule (IMS) is a technical event-driven (not time-driven) plan primarily concerned with product and process development. It forms the basis for schedule control and progress measurement, and relates engineering management events and accomplishments to the WBS. These events are identified either in the format of entry and exit events (e.g. initiate PDR, complete PDR) or by using entry and exit criteria for each event. Example exit criteria shown in Figures 16-1 and 16-2.

The program office develops an event-based schedule that represents the overall development effort. This schedule is usually high-level and focused on the completion of events that support the acquisition milestone decision process. An event-based schedule is developed by the contractor to include significant accomplishments that must be completed in order to meet the progress required prior to contract established events. The contractor also includes events, accomplishments, and associated success criteria specifically identified by the contract. DoD program offices can use the contractor's event-based schedule and the

System Requirements Review (SRR)	System Functional Review/Software Spec Review(SFR/SSR)	Preliminary Design Review (PDR)
• Mission Analysis completed • Support Strategy defined • System options decisions completed • Design usage defined • Operational performance requirement defined • Manpower sensitivities completed • Operational architecture available and reviewed	• Installed environments defined • Maintenance concept defined • Preliminary design criteria established • Preliminary design margins established • Interfaces defined/preliminary interface specs completed • Software and software support requirements completed • Baseline support/resources requirements defined • Support equipment capability defined • Technical architecture prepared • System defined and requirements shown to be achievable	• Design analyses/definition completed • Material/parts characterization completed • Design maintainability analysis completed/support requirements defined • Preliminary production plan completed • Make/buy decisions finalized • Breadboard investigations completed • Coupon testing completed • Design margins completed • Preliminary FMECA completed • Software functions and architecture and support defined • Maintenance tasks trade studies completed • Support equipment development specs completed

Figure 16-1. Sample Event-Based Schedule Exit Criteria

Critical Design Review Test Readiness Review (CDR/TRR)	System Verfication Review/ Functional Configuration Audit (SVR/FCA)	Physical Configuration Audit (PCA)
• Parts, materials, processes selected • Development tests completed • Inspection points/criteria completed • Component level FMECA completed • Repair level analysis completed • Facility requirements defined • Software test descriptions completed • Hardware and software hazard analysis completed • Firmware spt completed • Software programmers manual completed • Durability test completed • Maintinability analyses completed • Qualification test procedures approved • Producibility analyses completed	• All verification tasks completed • Durability tests completed • Long lead time items identified • PME and operational training completed • Tech manuals completed • Flight test plan approved • Support and training equipment developed • Fielding analysis completed • Provisioning data verified	• Qualification testing completed • All QA provisions finalized • All manufacturing process requirements and documentation finalized • Product fabrication specifications finalized • Support and training equipment qualification completed • All acceptance test requirements completed • Life management plan completed • System support capability demonstrated • Post production support analysis completed • Final software description document and all user manuals complete

Figure 16-2. Sample Event-Driven Schedule Exit Criteria (continued)

contractor's conformance to it for several purposes: source selection, monitoring contractor progress, technical and other reviews, readiness for option award, incentives/awards determination, progress payments decision, and similar activities.

The event-based schedule establishes the key parameters for determining the progress of a development program. To some extent it controls and interfaces with systems engineering management planning, integrated master schedules and integrated master plans, as well as risk management planning, system test planning, and other key plans which govern the details of program management.

The calendar or detail schedule is a time-based schedule that shows how work efforts will support tasks and events identified in the event-based schedule. It aligns the tasks and calendar dates to show when each significant accomplishment must be achieved. It is a key component for developing Earned Value metrics. The calendar schedule is commonly referred to as the detail schedule, systems engineering detail schedule, or SEDS. The contractor is usually required to maintain the relationship between the event and calendar schedules for contract required activities. Figure 16-3 shows the relationship between the system requirements, the WBS, the contractual requirements, the event-based schedule, and the detail schedule.

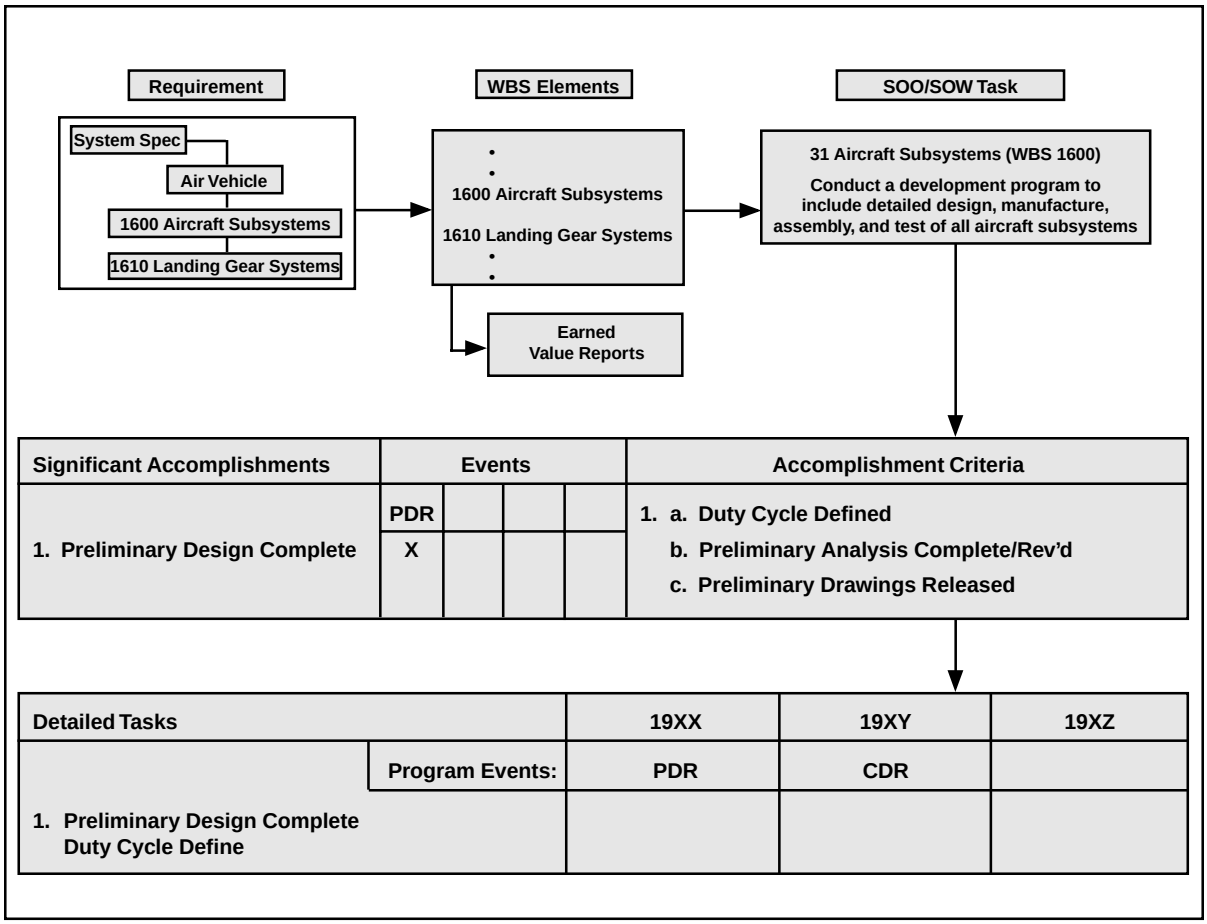

Figure 16-3. Event-Based—Detailed Schedule Interrelationships

Schedule Summary

The event-based schedule establishes the key tasks and results expected. The event-based schedule establishes the basis for a valid calendar-based (detail) schedule.